

General Linguistics

HPSG – Head-Driven Phrase Structure Grammar

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27 March 2013

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HPSG – brief introductions

- Levine, R. D. and Meurers W. D. (2005).
HPSG – Linguistic Approach, Formal Foundations, and Computer Realization.
In: Keith Brown (ed.): *Encyclopedia of Language and Linguistics*, 2nd edition, Elsevier, Oxford.
<http://www.ling.ohio-state.edu/~dm/papers/ell2-hpsg.pdf>
- Adam Przepiórkowski and Anna Kupść (2006):
HPSG for Slavicists. *Glossos*, 8.
<http://dach.ipipan.waw.pl/~adamp/Papers/2000-sling2k/>

HPSG – more extensive introductions

- with a stress on formalism and implementation issues:
[Richter(2004)]
<http://milca.sfs.uni-tuebingen.de/A4/Course/PDF/gramandpars.pdf>
- an HPSG textbook in English
[Sag & Wasow(1999)], [Sag et al.(2003)]
- an HPSG textbook in German
[Müller(2007)]
<http://hpsg.fu-berlin.de/~stefan/Pub/hpsg-lehrbuch.html>

HPSG – standard references

- Pollard & Sag (1987)
Information-Based Syntax and Semantics, Volume I,
Center for the Study of language and Information, Stanford
[Pollard & Sag(1987)]
- Pollard & Sag (1994)
Head-driven Phrase Structure Grammar,
Center for the Study of language and Information, Stanford & The
University of Chicago Press,
Chicago and London [Pollard & Sag(1994)]
- HPSG sites:
<http://hpsg.stanford.edu/>
<http://www.ling.ohio-state.edu/research/hpsg/>

HPSG – implementations

- An overview of implemented formalisms and grammars for several linguistic theories, including HPSG:
<http://hpsg.fu-berlin.de/~stefan/PS/implementations.pdf>

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History

- 1987: first monograph [Pollard & Sag(1987)]
- 1994: standard reference [Pollard & Sag(1994)]
- Immediate successor to Generalized Phrase Structure Grammar – GPSG [Gazdar et al.(1985)]
 - head features, unbounded dependencies, ID/LP format for rules
- Eclectic – inspired also by:
 - Functional Unification Grammar – FUG [Kay(1983)]
 - uniform notation for grammar rules, lexicon, representation
 - Lexical-Functional Grammar – LFG [Kaplan & Bresnan(1982)]
 - lexical rules
 - Categorical Grammar – CG [Ades & Steedman(1982)]
 - satisfying valency requirements
 - the Government and Binding paradigm – GB [Chomsky(1981)]
 - analyses of various language phenomena

Why HPSG?

- **Precision** of analysis, both in grammar and data
- **Integration** of diverse sources of knowledge
- **Declarative** grammar
- **Constraint satisfaction** system
- **Scaleable, implementable** grammars
- Psychological **plausability**

Main features 1/2

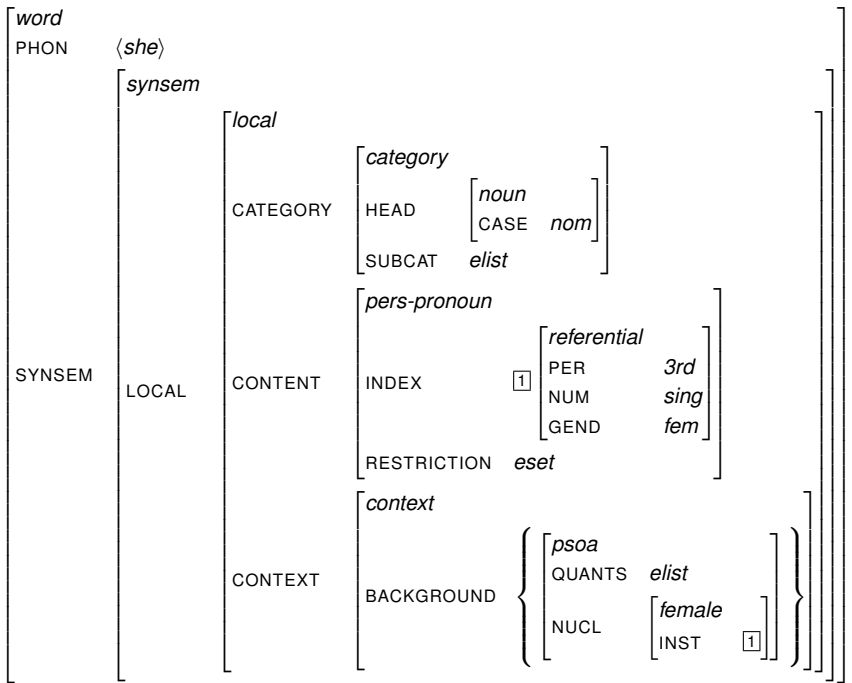
- HPSG grammar is a set of **axioms** – ‘constraints’
- The model: typed **feature structures**, defined in a **hierarchy** with multiple inheritance, for morphemes, words, phrases, sentences, ...
- **Lexical entries** and **grammar rules** as constraints on these expressions
- Constraints are combined and applied by **unification**
- Most info is stored in lexical entries, HPSG is very much **lexicalized** – ‘head-driven’

Main features 2/2

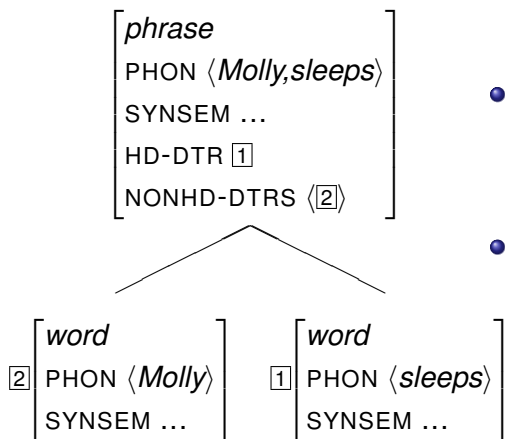
The concept of **sign** [de Saussure(1916)]

one description to model all properties of words and phrases:

- phonology/graphemics
- morphology
- syntax
- semantics
- pragmatics
- combinatory (syntagmatic) properties

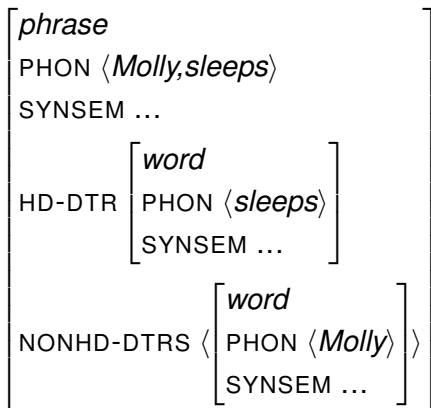


A simple sentence as a tree



- Edges just for readability, [1] and [2] are just values of the attributes HD-DTR and NONHD-DTR.
- HD-DTR and NONHD-DTR do not represent word order. Word order is determined by PHON.

The same sentence only as a feature structure



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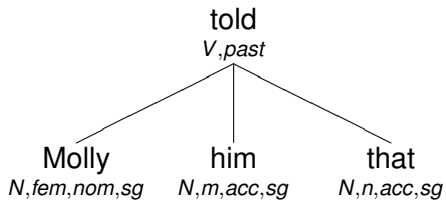
6 Semantics

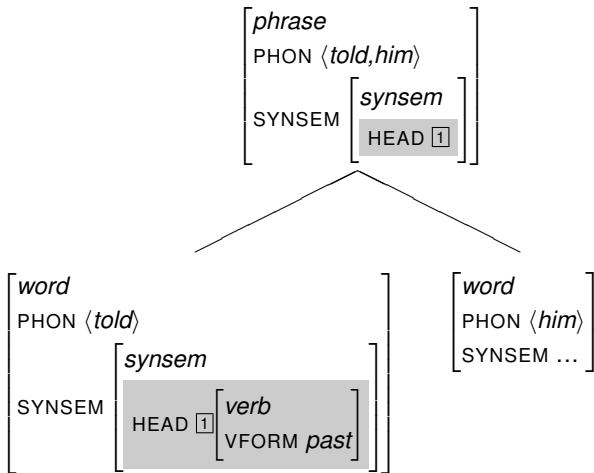
7 Unbounded dependencies

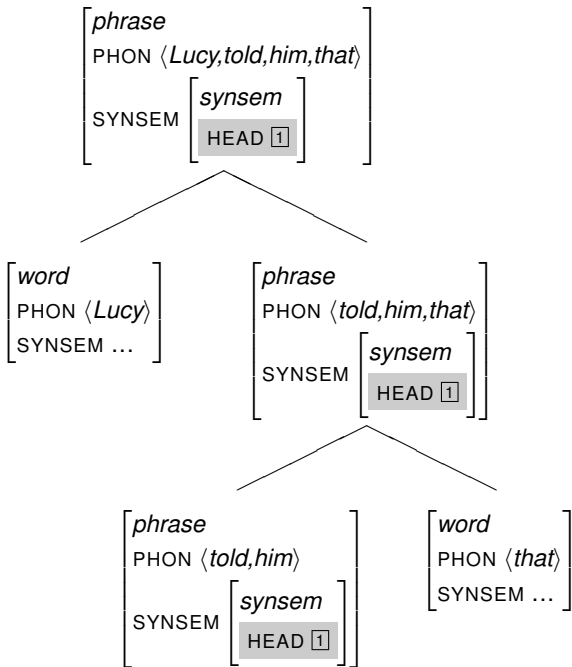
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Another sentence, with *head* features







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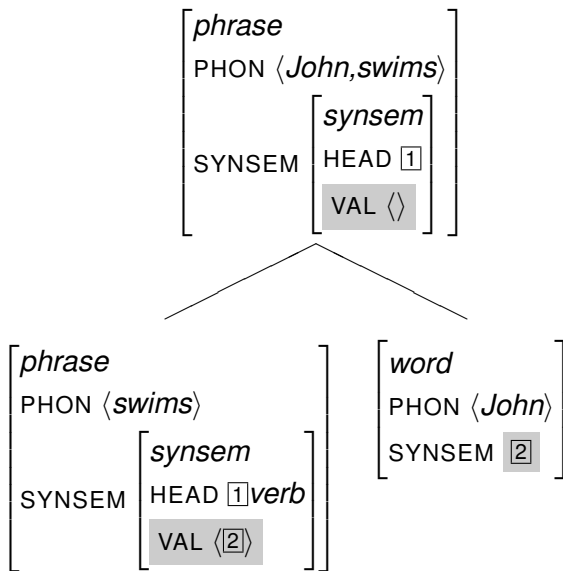
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- Arguments represented as complex categories in the lexical entry of the head (similar to categorial grammar)

verb	VALENCY
<i>swim</i>	⟨NP[<i>nom</i>]⟩
<i>rain</i>	⟨NP[<i>it</i>]⟩
<i>hate</i>	⟨NP[<i>nom</i>], NP[<i>acc</i>]⟩
<i>look</i>	⟨NP[<i>nom</i>], PP[<i>at</i>]⟩
<i>give</i>	⟨NP[<i>nom</i>], NP[<i>acc</i>], NP[<i>acc</i>]⟩
<i>give</i>	⟨NP[<i>nom</i>], NP[<i>acc</i>], PP[<i>to</i>]⟩
<i>try</i>	⟨NP[<i>nom</i>], VP[<i>inf</i>]⟩
<i>persuade</i>	⟨NP[<i>nom</i>], NP[<i>acc</i>], VP[<i>inf</i>]⟩
<i>say</i>	⟨NP[<i>nom</i>], S[<i>that</i>]⟩



Abbreviations

S

$$\left[\begin{array}{l} \textit{phrase} \\ \text{SYNSEM} \left[\begin{array}{l} \textit{synsem} \\ \text{HEAD verb} \\ \text{VAL } \langle \rangle \end{array} \right] \end{array} \right]$$

VP

$$\left[\begin{array}{l} \textit{phrase} \\ \text{SYNSEM} \left[\begin{array}{l} \textit{synsem} \\ \text{HEAD verb} \\ \text{VAL } \langle \textit{sign} \rangle \end{array} \right] \end{array} \right]$$

V

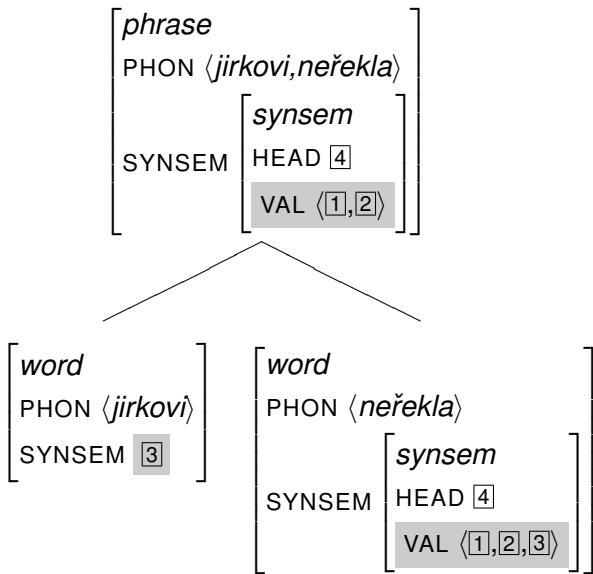
$$\left[\begin{array}{l} \textit{word} \\ \text{SYNSEM} \left[\begin{array}{l} \textit{synsem} \\ \text{HEAD verb} \\ \text{VAL list} \end{array} \right] \end{array} \right]$$

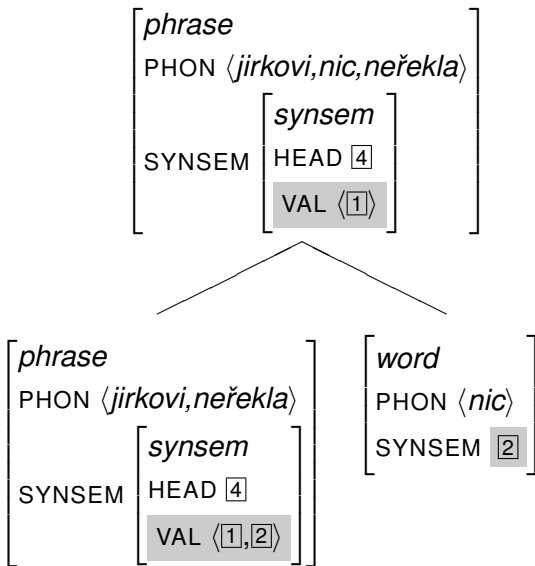
NP

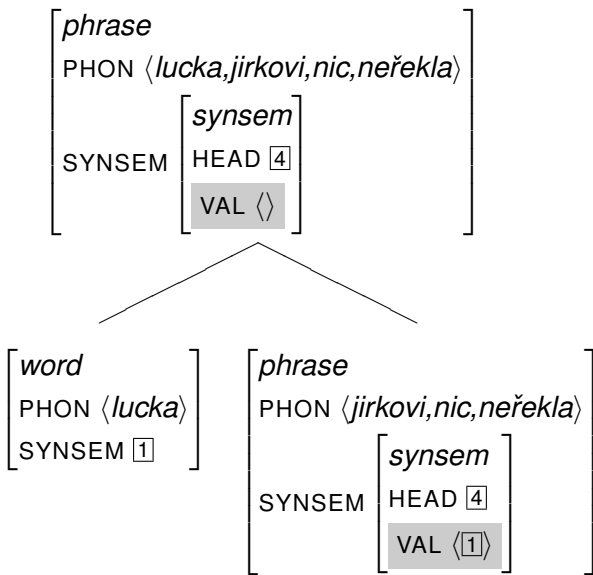
$$\left[\begin{array}{l} \textit{phrase} \\ \text{SYNSEM} \left[\begin{array}{l} \textit{synsem} \\ \text{HEAD noun} \\ \text{VAL } \langle \rangle \end{array} \right] \end{array} \right]$$

Valency

- Unlike *head features*, valency can change with the level of projection.
- Thus, the list of valency requirements cannot be included in the value of the attribute HEAD.
- *Lucka Jirkovi nic neřekla*
'Lucy didn't say anything to Jirka.'







Valency (summary)

- The features HEAD and VAL provide information
 - about the word's syntactic word class and
 - the degree its valency requirements are satisfied.
- This information is partially implicit in the standard atomic categories of CF grammar: N, N', NP, V, VP, S. These are often used as abbreviations.
- Often the attribute CATEGORY or CAT groups these two features, serving as the locus of the item's syntactic information.
- CAT is just one of *synsem*'s attributes.
- Rather than *signs*, valency lists include *synsems*. Why?

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The grammar architecture

- Components of a grammar:
 - **Signature** (defines possible objects)
 - **Theory** (specifies constraints on the objects)
- Components of a theory:
 - **Lexical entries** (word-specific constraints)
 - **Lexical rules**
(expressing lexical generalizations – morphology, alternations)
 - **Principles** (syntactic regularities)
 - **Schemas** (relating phonology and syntactic structure)
 - **Relational constraints** (list operations etc.)

Rules

- Abstracting from word order:
 - ID/LP rules (Immediate Dominance vs. Linear Precedence)
 - dominance in DTR, precedence in PHON
- Abstracting from word classes:
 - V, N, P, A
- A general schema:

$$\bullet \text{ H [VALENCY } \boxed{1}] \longrightarrow \text{ H [VALENCY } \boxed{1} \oplus \langle \boxed{2} \rangle] \quad \boxed{2}$$

- Possible instantiations:

$$\bullet \text{ V [VALENCY } \boxed{1}] \longrightarrow \text{ V [VALENCY } \boxed{1} \langle \rangle \oplus \langle \boxed{2} \text{ NP} \rangle] \quad \boxed{2}$$

$\boxed{2}$ *John swims.* $\boxed{2}$ *Mary [loves strawberries].*

$$\bullet \text{ V [VALENCY } \boxed{1}] \longrightarrow \text{ V [VALENCY } \boxed{1} \langle \text{NP} \rangle \oplus \langle \boxed{2} \text{ NP} \rangle] \quad \boxed{2}$$

loves $\boxed{2}$ *strawberries*

$$\bullet \text{ N [VALENCY } \boxed{1}] \longrightarrow \text{ N [VALENCY } \boxed{1} \langle \rangle \oplus \langle \boxed{2} \text{ DET} \rangle] \quad \boxed{2}$$

$\boxed{2}$ *[my younger sister's] boyfriend.*

More abstractions

$$H [\text{VALENCY } \boxed{4}] \longrightarrow H [\text{VALENCY } \boxed{4} \oplus \langle \boxed{5} \rangle] \quad \boxed{5}$$

$$\textit{phrase} \rightarrow \left[\begin{array}{l} \text{PHON } f(\boxed{1}, \boxed{2}) \\ \text{HEAD } \boxed{3} \\ \text{VALENCY } \boxed{4} \\ \text{HD-DTR } \left[\begin{array}{l} \text{PHON } \boxed{1} \\ \text{HEAD } \boxed{3} \\ \text{VALENCY } \boxed{4} \oplus \langle \boxed{5} \rangle \end{array} \right] \\ \text{NONHD-DTRS } \langle \boxed{5} [\text{PHON } \boxed{2}] \rangle \end{array} \right]$$

- The rule schema includes several types of info:
 - dominance
 - concatenation of PHON values
 - valency satisfaction
 - head features sharing

Principles

- Schema

$$phrase \rightarrow \left[\begin{array}{l} PHON f([1],[2]) \\ HD-DTR [PHON [1]] \\ NONHD-DTRS [5] [PHON [2]] \end{array} \right]$$

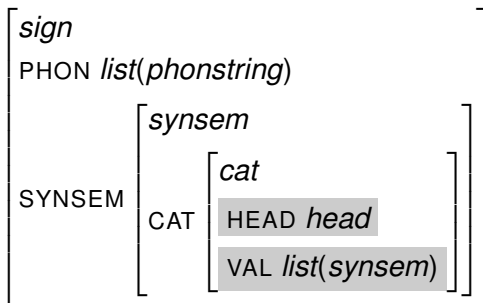
- Head Feature Principle

$$phrase \rightarrow \left[\begin{array}{l} HEAD [3] \\ HD-DTR [HEAD [3]] \end{array} \right]$$

- Valency Principle

$$phrase \rightarrow \left[\begin{array}{l} SYNSEM | VALENCY [4] \\ HD-DTR [VALENCY [4] \oplus \langle [5] \rangle] \\ NONHD-DTRS [5] \end{array} \right]$$

The type *sign* (simplified)



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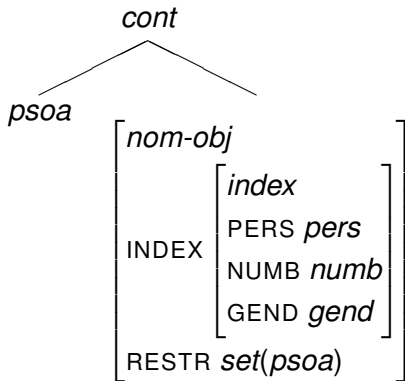
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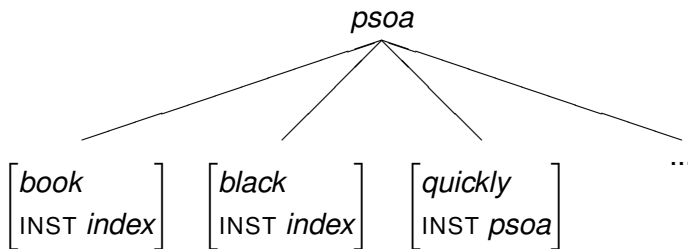
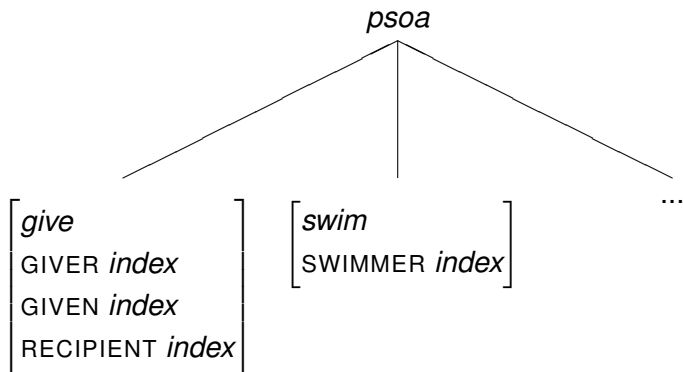
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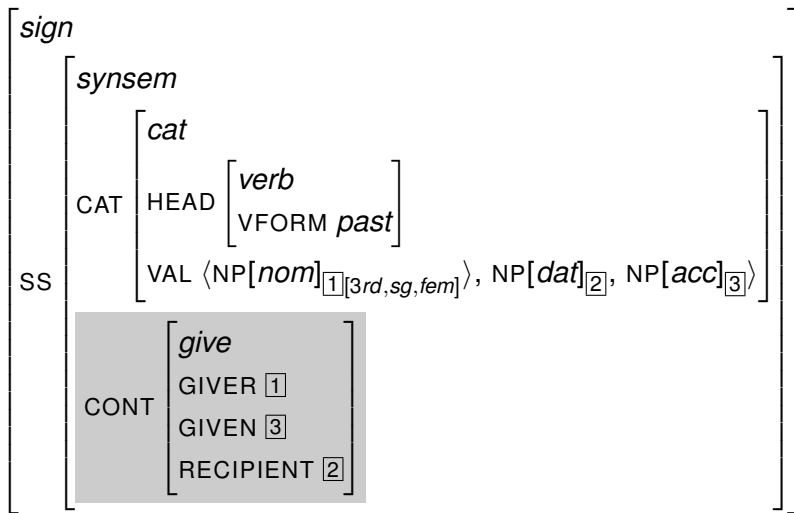
Semantics

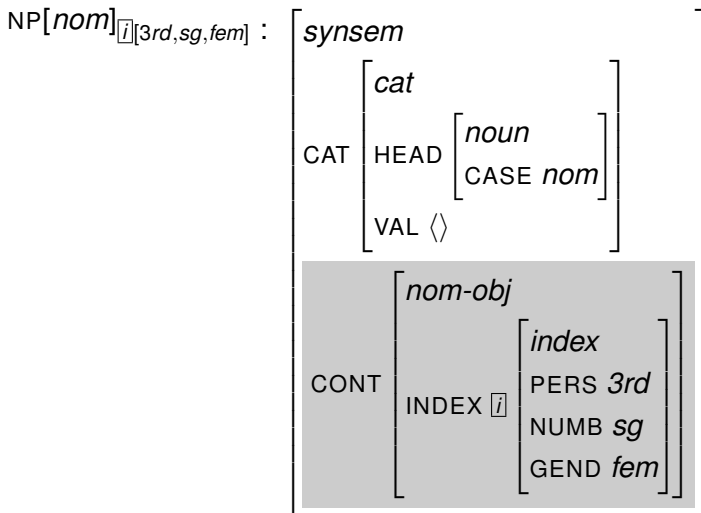
$$\left[\begin{array}{l} \textit{sign} \\ \text{PHON } \textit{list}(\textit{phonstring}) \\ \\ \text{SYNSEM} \left[\begin{array}{l} \textit{synsem} \\ \text{CAT } \textit{cat} \\ \text{CONT } \textit{cont} \end{array} \right] \end{array} \right]$$





Lexical entry for *dala*:



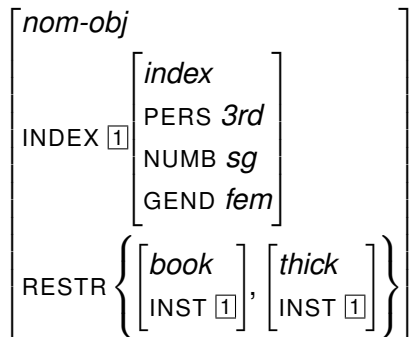


A reminder: Lexicon is formally a huge disjunction of constraints on the type *word*: $word \rightarrow entry1 \vee entry2 \vee entry3 \vee \dots$

Lexical entry for *kniha* 'book', the value of CONT:

<i>nom-obj</i>									
INDEX [1]	<table style="border-collapse: collapse;"> <tr> <td style="border-right: 1px solid black; padding-right: 5px;"><i>index</i></td> <td style="padding-left: 5px;"></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 5px;">PERS <i>3rd</i></td> <td style="padding-left: 5px;"></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 5px;">NUMB <i>sg</i></td> <td style="padding-left: 5px;"></td> </tr> <tr> <td style="border-right: 1px solid black; padding-right: 5px;">GEND <i>fem</i></td> <td style="padding-left: 5px;"></td> </tr> </table>	<i>index</i>		PERS <i>3rd</i>		NUMB <i>sg</i>		GEND <i>fem</i>	
<i>index</i>									
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<i>book</i>									
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NP *tlustá kniha* 'a thick book', the value of CONT:



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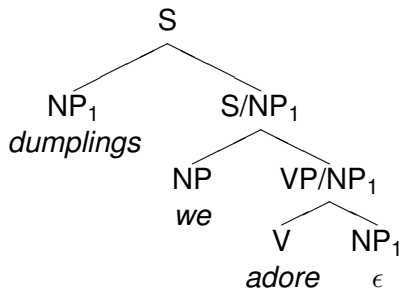
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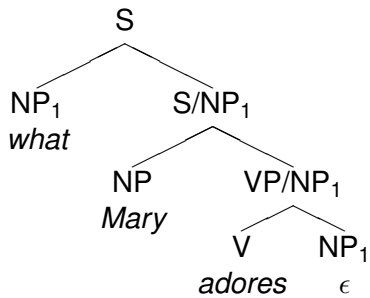
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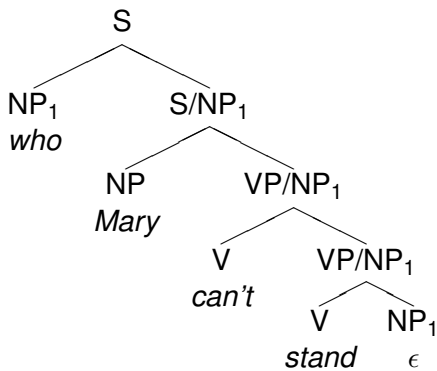
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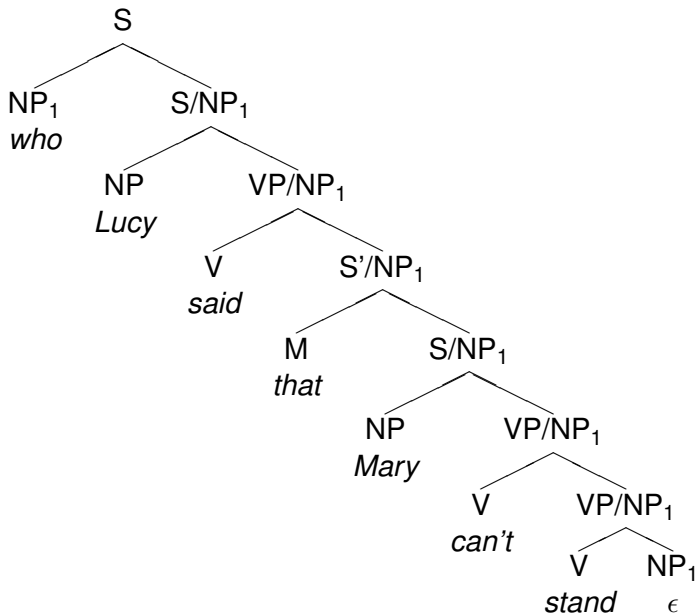
9 References

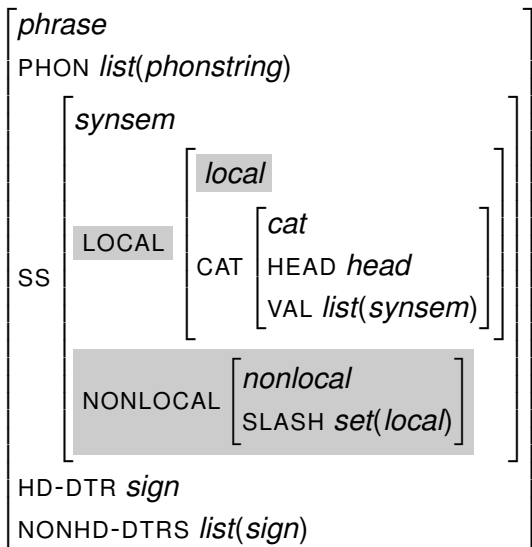
Unbounded dependencies: LOCAL/NONLOCAL, *filler/gap*

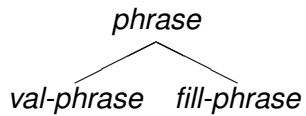




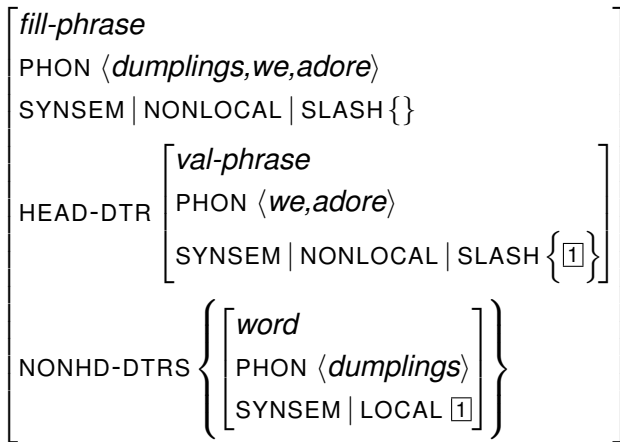








Filler phrase



Trace

$$\left[\begin{array}{l} \textit{word} \\ \text{PHON } \langle \rangle \\ \text{SYNSEM } \left[\begin{array}{l} \text{LOCAL } \boxed{1} \\ \text{NONLOCAL | SLASH } \left\{ \boxed{1} \right\} \end{array} \right] \end{array} \right]$$

fill-phrase
P ⟨*dumplings,we,adore*⟩
..SUBJ ⟨⟩..COMPS ⟨⟩..SLASH {}

word
P ⟨*dumplings*⟩
..LOCAL [1]

val-phrase
P ⟨*we,adore*⟩
..SUBJ ⟨⟩..COMPS ⟨⟩..SLASH { [1] }

word
P ⟨*we*⟩
SS [3]

val-phrase
P ⟨*adore*⟩
..SUBJ [3]..COMPS ⟨⟩..SLASH { [1] }

word
P ⟨*adore*⟩
..SUBJ [3]..COMPS [2]..SLASH {}

word
P ⟨⟩
SS [2] [LOCAL [1]]
..SLASH { [1] }

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word

PHON ⟨já⟩

synsem

CAT [cat
HEAD [noun
CASE nom]
VAL ⟨ ⟩]

SS

CONT [nom-obj
INDEX [1
index
PERS 1st
NUM sg
GEND gend]
RESTR { }]

CTX

[ctx
C-INDS [c-inds
SPEAKER [1]
ADDRESSEE index]
BCKGRND { }]

word
PHON ⟨vy⟩

synsem

CAT [*cat*
HEAD [*noun*
CASE *nom*]
VAL [SUBJ ⟨⟩, COMPS ⟨⟩]]

CONT [*nom-obj*
INDEX [1] [*index*
PERS *2nd*, NUM *pl*, GEND *gend*]
RESTR { }]

SS

CTX [*ctx*
C-INDS [*c-inds*
SPEAKER [2]
ADDRESSEE [1]]
BCKGRND { [*honor*
HONORER [2]
HONORED [1]], [*non-aggreg*
INST [1]] }]

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<http://milca.sfs.uni-tuebingen.de/A4/Course/PDF/gramandpars.pdf>.



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